Soil Tillage in Agroecosystems

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Preface

Soil management has been the main feature of land use since humans settled the land and started to grow crops thousands of years ago. In those prehistoric days, soil-management objectives were simple: to sustain soil fertility and secure food productivity. The long evolutionary pathway that led to our modern world has teemed not only with inventions, discoveries, and technological developments but also with theories and assumptions about handling agricultural soils that have not changed the paramount need for soil management in agricultural land use. On the contrary, emerging knowledge, in particular with regard to the environmental impacts of today's intensive production systems, has imposed further objectives for consideration. Soil erosion, nonpoint environmental pollution, and declining ecosystem stability have all been subjects of worldwide public concern, scientific input, and political debate for many decades.

Soil tillage is, and will remain, the guiding component of soil management and consequently has far-reaching implications for agroecosystems. Understanding structures and functions of soil ecosystems under various tillage/no-tillage practices is an essential requirement for any future farming concepts. This book emphasizes these aspects in all 12 chapters, highlighting both the short- and long-term effects of soil-cultivation practices on the soil ecosystem below and above the soil surface. Chapter 1 presents the main tillage concepts, describes available farm machinery, and highlights aspects of the energy needs and costs of various soil-management technologies. Chapter 2 emphasizes soil-management effects on soil structural features, including physical and hydrological criteria, to evaluate various tillage techniques with regard to soil structural stability, water storage, preferential flow, and leaching. Chapter 3 examines tillage impacts on soil microphytes in pedoecosystems. Shifts in microbial activity and biomass under distinct soil-management concepts, ranging from no-tillage to annual plowing, are analyzed, focusing on mycorrhizal fungi, rhizobia, amonifiers, and nitrifiers. Chapter 4 considers the implications of changed soil environments induced by the different tillage regimes for soil nutrient cycling and reservoirs. Particular attention is given to the breakdown of soil organic matter, mineralization processes, and the long- and short-term effects of the various soil-cultivation methods in common use.

Responses of field vegetation and the field-associated fauna under different tillage practices are the subject matter of the following chapters. Chapter 5 highlights tillage-system implications for seed-germination patterns for both weed and crop seeds. Interactions between tillage-induced seed position in the soil profile and seed behavioral responses to light, temperature, soil moisture, and gases are explored in detail in this chapter. Shifts in the germination pattern of weeds result in changed weed communities. Chapter 6 reviews the impacts of different tillage regimes on weed infestation incidence, species diversity, and tillage-induced shifts in weed communities of arable fields. The ecological, economic, and societal aspects of the functions of wild flora within crop ecosystems are explored. Chapter 7 provides a comprehensive overview of tillage impacts on plant pathogens, with a consideration of the main arable crop species. The review and conclusions are embedded within

the concept of the whole farming system. Likewise, Chapter 8 addresses the influences of tillage on slugs, known to be of increasing significance in humid temperate zones. Responses of slug antagonists to the different tillage strategies are reviewed, and integrated slug-management tactics are outlined. The interactions between tillage practices and earthworms constitute the foundation of Chapter 9. The significance of earthworms in soil formation, structural stability, water permeability, and other criteria make it essential to safeguard their benefits in agroecosystems. Much like earthworms, the roles of selected groups of soil-inhabiting fauna are stressed in Chapter 10, with an emphasis on mesostigmatic Acarina (mites), Collembola (springtails), Dipteran larvae, and nematodes, and the responses of these groups and the alternation in their antagonistic interactions with other soil coinhabitants. Chapter 11, which addresses tillage effects on epigeal predatory fauna, completes the discussion of tillage impacts on beneficial fauna. Supported by extensive and updated documentation on the tillage effects on carabids, staphylinids and spiders are discussed, and appropriate conclusions are drawn. Chapter 12 concludes by evaluating tillage effects with a view to long-term ecosystem stability, soil fertility, and functioning.

This book offers a broad and comprehensive view of the interrelations of multifaceted tillage practices and the biological, chemical, and physical components of soil ecosystems. Tillage effects are highlighted within the context of the whole farming system to stress that these other components greatly affect the responses of soil ecosystems to tillage practices. This understanding is essential to assess the role of tillage concepts in future farming system design aimed at maintaining resources, sustaining productivity, and minimizing environmental pollution. For farming and nonfarming communities the healthy functioning of agroecosystems is an essential symbol of stability and environmental safety. I hope that this book may contribute to the realization of these objectives.

Adel El Titi

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Adel El Titi

About the Editor

Adel A. El Titi, Ph.D., is a senior researcher in integrated pest management, entomology, and integrated farming systems and head of section IPM–arable crops at the State Institute for Plant Protection in Stuttgart, Germany.

In 1965, he received his B.S. in plant protection from the University of Cairo, Egypt, Diplom Agric in 1968, and Ph.D. in 1972 from the University of Göttingen in Germany. Dr. El Titi is a fellow of various national and international organizations and working groups. With the multidisciplinary on-farm research project of Lautenbach, Germany, he pioneered an applied research track in agriculture aimed at the development and implementation of an integrated farming system in arable crops. Focusing on soil pests he addressed long-term implications of soil tillage regimes for both soil fauna and weed communities. Dr. El Titi chaired the IOBC/WPRS Commission on Integrated Production and Endorsement of Guidelines for 7 years and for 12 years has served on the editorial boards of various scientific journals including *Agriculture, Ecosystems and Environment* and *Journal of Sustainable Agriculture*. He is the author of some 75 papers and 3 book chapters, coeditor of a book, and editor of 25 radio and 5 TV broadcasts on the topic of IFS. Dr. El Titi has served the EU Commission as consultant and evaluator, mainly on sustainable concepts of agriculture, and taught at the University of Kassel as an external lecturer on soil ecosystems, supervised Ph.D. studies at the Universities of Tübingen, Heidelberg, Hohenheim, and Weihenstephan in Germany. His annual IPM courses offered to state extension officers represented a significant contribution to the dissemination of information about IPM/IFS in southwest Germany. As an invited speaker he has contributed to various international conferences and symposia. Dr. El Titi has received numerous research grants from national and EU sources and served as coordinator of international interdisciplinary research projects on sustainable approaches in European agriculture.

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